BOARD OF EDUCATION.

Educational Pamphlets, No. 30.

AN EXPERIMENT IN INDUSTRIAL RESEARCH.

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PREFATORY NOTE.

The scheme for the organisation and development of scientific and industrial research, which was outlined in the recently published parliamentary paper [Cd. 8005] and the establishment of a Committee of the Privy Council appointed to direct the application of any sums provided by Parliament for the purpose, make it opportune in the opinion of the Board to publish an account of the attempt made by certain Universities in the United States to provide for the necessary co-operation between the Universities and Manufacturers in the promotion of research. The following Report on the scheme for Industrial Fellowships, inaugurated by Professor Kennedy Duncan, has been prepared by Mr. T. Ll. Humberstone, Mitchell Student of the University of London, and is issued with the consent of the Mitchell Trustees. The Report is based mainly on observations made at the time of Mr. Humberstone's visit to the Universities of Kansas and Pittsburgh, in 1913, but has been supplemented by later information obtained from America. It will be understood that the Board do not necessarily endorse the opinions expressed in the Report.

Office of Special Inquiries and Reports,
August, 1915.

AN EXPERIMENT IN INDUSTRIAL RESEARCH.

Industrial research or scientific research in its relations to industrial and commercial applications is a subject of great difficulty and importance which has become increasingly urgent owing to the economic disturbances caused by the European war. The purpose of the following Report is to describe a scheme, devised by the late Professor Robert Kennedy Duncan, for co-operation between Universities and the scientific industries, which has been successfully worked in certain Universities in the United States—a scheme of which it may confidently be said that it has found a solution for some of the difficulties which beset the subject.

Dr. Duncan has explained the principles underlying his scheme of Industrial Fellowships in an article published in the Journal of Industrial and Engineering Chemistry (August, 1909). He postulates that it is not the function of a University professor of industrial chemistry to establish special courses and laboratories for undergraduates who propose to become industrial chemists, because, by taking such courses, the undergraduate would probably be deprived of just so much pure chemistry, *i.e.*, real chemistry. The University, as distinct from a technical school, rightly insists that the training of undergraduates shall consist of educational or cultural subjects. Current industrial practice is always ahead of text-book presentation and laboratories of industrial chemistry having apparatus and processes in miniature fail for the most part to serve any good purpose, and may give the student an exaggerated impression of his possible usefulness in the factory to which he may subsequently go. It follows that the study of industrial chemistry and other applied sciences, if pursued at the University at all, should be undertaken after the undergraduate course is finished.

As to the future demand from the industries for a large supply of well-trained technical chemists, there appeared to be no reason for doubt. Dr. Duncan's opinion of American factory practice from the standpoint of scientific efficiency was at this time not very favourable. Excessive tariffs, he says, had lessened competition and a plentiful supply of raw material gave a false sense of security. The manufacturer failed to appreciate problems which he ought to have tackled, preferring to maintain his high profits by means of business intrigue and to make good the waste in his factory by combinations for the elimination of competition. Recent years had brought about a change in these conditions. Wasteful production was bidding fair to result in over-production; in the practice of business intrigue no manufacturer had anything to learn from another; the wealth of raw material had in a large measure been aggregated into the holdings of a few men who would release them only at an onerous and distressful rate; and the tariff, high as it

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was, failed to exclude many articles made under scientific supervision. A vigorous demand was arising for the reduction of the tariff. These conditions produced a great anxiety on the part of American manufacturers to secure factory efficiency and to invoke the help of science.

In an address by Dr. Duncan on industrial research, reprinted in the Journal of Industrial and Engineering Chemistry of March, 1911, he refers to the lack of co-ordination and co-operation in industrial research both between the Universities and the industries and among the industries themselves, and to the general ignorance of the best methods of conducting factory research. Chemists in the United States are often "hired" by the week or by the month, contracts of one or two years being comparatively rare. Reliance on merit as the only guarantee of employment is characteristic of American industry, but in the case of highly-trained chemists, the system tends to induce a lack of professional spirit and organisation and the resulting insecurity of tenure creates an atmosphere unfavourable for scientific work. A distinction is sometimes drawn between lower and higher academic qualifications in respect of salary; but in a large number of cases the corporation cares very little, or not at all, what degree a man may have. One official said, "We call them all doctors, anyhow." Hours of work and vacations appear to follow ordinary factory practice. To the important question, "Do members of the research "department sign a contract resigning all rights to any "discoveries made in your employ?" the general answer is "Yes," qualified sometimes by an "opportunity to acquire "stock," or "a cash present," but never by royalties or a share in the profits. There is a wide variety of practice as to the responsibility of a Director of Research—it may be to the president of the company, the vice-president, the superintendent, the consulting engineer or the manager of the works. Summing up the result of his personal observations, Dr. Duncan declares that 95 per cent of so-called factory research is worse than loss, because the failure makes it impossible for the factory to appreciate the advantage of applied science. The failure is usually due to an incapacity to select chemists, inexperience in dealing with them, and ignorance of the facilities in the way of laboratories and libraries which should be placed at their disposal. He states that he has met instances of chemists of high training, creative power, and practical character, who are overburdened with routine drudgery and subjected to the interference of factory foremen, and are working under an entire misapprehension on the part of the officials of the company as to their possibilities and value. In other cases, failure is due to the incapacity of the chemist employed. For this state of things, the University professor of pure science who is consulted by the manufacturer, but makes no serious attempt to study the qualifications required in a technical chemist, and may indeed regard the utilisation of science for human needs as more or less degrading to science itself, is often to blame. Dr. Duncan contends that success in industrial research demands all the qualities which are necessary for success in pure science, together with other qualities, such as the ability to deal with workmen and to control foremen, which are not essential in the University laboratory.

On the wider question of the University course for a technical chemist, Dr. Duncan makes some important suggestions. There is, he says, considerable dissatisfaction with the type of instruction offered after graduation to young men who desire to enter commercial laboratories, on account of the antiquated and cumbersome methods which are taught in the Universities and the neglect of the time element in making analyses. The inability which university-trained men show to distinguish between absolute accuracy and practical accuracy is a matter of frequent comment by writers on the subject. During the educational period of a man's course, the student must be taught to work with the strictest scientific accuracy. In his more specialised post-graduate training, different methods must be adopted. Again, there is, in Dr. Duncan's opinion, a tendency in the United States to make the chemical training in Universities too analytical in character. Courses in such subjects as metallurgy, advanced inorganic and physical chemistry are taught analytically by analytically-minded men. More importance should be attached, he thinks, to the discipline and methods of organic chemistry, the only subject in the chemical curriculum in which a student is trained in synthetic working and thinking. "Both in the organic and inorganic fields of "industrial chemistry, and outside of the routine testing-"laboratories, the problems that are perhaps most important "to industrialists are synthetic problems."

Accepting this as a fair statement of the case, it is easy to understand the difficulty of the manufacturer, outside a few large and well-organised firms, in making a start in the application of scientific methods to his problems. He may not know the real nature of these problems, their relative importance, and the kind of knowledge required for their solution. He has no means of judging the qualifications of the men available for his researches, or the expenditure on laboratories and equipment which the work would entail. He has had no experience of co-ordinating research work with the operations of the factory or of estimating the progress made. On the basis of these considerations, it appeared probable that the American manufacturer would welcome some method of having his special problems investigated for a definite outlay, so that, if the results were useless, he would at any rate know the exact amount of his pecuniary loss; and Dr. Duncan therefore set himself to study the special questions which arise in adapting the work to University conditions. In the result, he worked out the scheme of Industrial Fellowships which came into operation in the University of Kansas in 1907 and in Pittsburgh University some three years later.

Under this scheme, a contract* is entered into between the manufacturer and the University in which the object of the research is precisely defined. The contract provides that the Fellow selected to conduct the investigation desired shall devote his whole time to the research, with the exception of three hours a week, which he may devote to instructional work in the chemical department. The Fellow is a member of the University, and pays all the regular fees with the exception of fees for laboratory and supplies, for which the instruction he gives in the University is accepted in lieu, unless in the opinion of the University his demands become excessive, in which case the manufacturer who provides the funds for the Fellowship is expected to reimburse the University. In some instances the manufacturer makes a specific grant for expenditure on apparatus. The contract further provides that the Fellow shall work under the direction of the professor of industrial chemistry and shall forward to the manufacturer periodically, through the professor, reports on the progress of the work. The manufacturer agrees to pay to the University an annual sum for the emoluments of the Fellow during the tenure of the Fellowship which ordinarily extends to two years, this sum being paid over to the Fellow by monthly instalments. A clause follows relating to the proprietorship of inventions made by the Fellow, providing usually for a payment of ten or some other percentage of the net profits arising from discoveries, to be commuted at the desire of either party for a sum fixed by arbitration. The Fellow is required at any time to take out patents at the expense of the manufacturer on condition that the Fellow, whose ownership of the invention is expressly acknowledged, shall assign his rights to the manufacturer on the terms set out. During the tenure of the Fellowship, the Fellow may publish any results of his investigation which, in the opinion of the manufacturer, do not injure his interests. At the expiration of the Fellowship, the Fellow is required to prepare a monograph embodying the results of his researches, a copy of which goes to the manufacturer and another to the University on the understanding that after the expiration of three years, but not before, the University shall be at liberty to publish it for the use and benefit of the public. Meanwhile, the manufacturer has full liberty to make any use of the inventions he may desire. The foregoing statement represents the characteristic features of all the agreements for Industrial Fellowships which have been established. The emoluments have varied in different Fellowships, as will be seen, and in some cases provision has been made for a composite Fellowship, giving employment to several workers.

* *See* Appendix I., p. 14 below.

It may be useful to examine in greater detail the conditions of the Fellowship in relation to all the parties concerned—(1) the University; (2) the manufacturer; (3) the Fellow; (4) the public.

Considering first the University, it is evident that men are being trained in research methods, and that knowledge is being increased. For the most part, the results of the researches are of a practical character, and are of direct commercial value resulting in patents or special processes. But it frequently happens that during the progress of the researches light is thrown on questions of purely scientific interest. Instances will be given in due course. The University has also the advantage of securing the services of the Fellows as instructors on reasonable terms. The influence of a body of men, well qualified in an academic sense—many have already taken their doctor's degree—keen on their particular work, and enthusiastic as to the value of research and the opportunities for research offered by applied science, is an asset of considerable value to the University.

The manufacturer is freely given all the resources of a great institution in laboratories, museums, and libraries, an equipment immeasurably larger than is possessed by any but a few very large firms; and his special problems are investigated directly by the Fellow and indirectly by experts in all departments of science, mathematical, physical, and bacteriological, whose opinion can be obtained by consultation by the Fellow. But the manufacturer is entirely free from the responsibility of selecting the specialist best qualified to investigate his problems or of supervising his work; and at the termination of the Fellowship, he is able to secure the services of a man conversant with the problems arising in his particular industry. Under the terms set out in the contract, he secures certain rights with reference to discoveries made during the Fellowship. His outlay for all these services is exactly defined. With some exceptions, in the case of each of the Fellowships established, the manufacturer entered deliberately into a business arrangement of a somewhat speculative character, certainly with no guarantee of results fully equivalent to the outlay involved. He is not in any way regarded as a benefactor of the University. This aspect of the scheme must be specially noted because it distinguishes it from the donations and endowments which industrial firms have sometimes offered to technical colleges and universities, the return for which has been of an indirect and often of a shadowy character. As regards the actual value to the manufacturer of the results obtained under the scheme, it should be remembered that these results are not always limited to solution of the original problem proposed for investigation, for it frequently happens that some kindred scientific question affecting the working of the factory is studied and solved with profitable results to the manufacturer. Dr. Raymond F. Bacon writes on this point:—

> "I feel firmly convinced, from the experience in this work, that almost any manufacturer having a trained man giving his whole time and attention to the problems and difficulties of his particular company, is practically certain to reap a greater monetary return than the amount of money expended in the investigation, and that in very many cases he will obtain results of such far-reaching importance that the ultimate reward may be many times the outlay."—(Journal of the Franklin Institute, November, 1914.)

The advantages of the scheme to the selected Fellow are so obvious as hardly to need enumeration. He is brought into direct contact with a manufacturer and a specific problem, and carries on his investigation under many advantages—free from the interference which working in a factory often implies, within easy reach of library facilities, able to consult his colleagues among the industrial Fellows, who may all be regarded as specialists in other allied departments, invited to submit his difficulties to the director of the laboratories and to consult other members of the University staff, enjoying the free use of the factory and the ability to test his processes under industrial conditions, adequately remunerated and assured of a good return from any discoveries of commercial value he may make during the tenure of his Fellowship, and finally training himself in the scientific aspects of some industry with a good chance of securing permanent employment at an adequate salary and with a recognised status.

The advantages of the scheme to the general public are indirect. All progress in applied science must, in course of time, lead to cheaper commodities and increased amenities in daily life. The department of industrial chemistry may be regarded also as an educational department, differing from others, however, in the relatively small cost to the University and thus indirectly to the public. Increased efficiency of industrial organisation, whether brought about by the application of scientific agency or any other method, must in the long run accrue to the benefit of the whole nation.

It should be noted that the Director of the Industrial Research Laboratories has no personal interest in a pecuniary sense in the success or failure of the work of any of the Fellows. Dr. Duncan regarded this condition as absolutely essential in order that manufacturers may be willing to impart to him secret information as to processes conducted in their works and to consult him freely on all questions relating to the proposed research. This privilege which the Director enjoys of obtaining information from the particular manufacturer, and from many other special sources, is one of the most valuable features of the scheme, as it places the Fellow in an advantageous position with respect both to the private worker and the factory chemist. The spirit of co-operation which has arisen among the industrial Fellows, and their loyalty to the laboratory and its chief, are noteworthy characteristics soon detected by the visitor to the laboratories. This loyalty was well deserved, for Dr. Duncan spared himself no trouble in advising his Fellows, in obtaining special information on the problems they had under investigation, and in securing for them the apparatus and equipment required for their work. But there is a general feeling in the laboratories that, however valuable the advice and assistance of the Director in any research may have been, the full credit for the results is freely accorded to the particular Fellow by whom they have been produced.

Lists of the Fellowships established, both in the University of Pittsburgh and in the University of Kansas, with the names of the Fellows, date of establishment and emoluments, are appended. (*See* Appendix II., pp. 16–24 below). The following notes on some of the researches carried out under the scheme have been prepared with a view to illustrating the characteristics of the scheme to which attention has been drawn.

The investigation on diastase developed into a research on the construction of a scientific fodder from alfalfa whereby its dietetic content may be readily conserved by a process of drying.

The study of the chemistry of bread by Dr. Kohmann led to a valuable discovery for the utilisation of stale bread in the manufacture of new bread. He also succeeded in standardising the manufacture of a special kind of bread made extensively in the Western States and known as "salt rising" bread, which was formerly made in an empirical manner. Dr. Kohmann isolated the particular bacterium concerned, and by preparing the culture on a large scale, placed the manufacture of this type of bread on a scientific basis.

As the result of the fellowship on casein, a method was discovered of isolating casein from buttermilk in a form identical with that obtained from skim milk.

The research on the improvement of enamel led to the discovery of a highly resistive enamel for steel. The Fellows concerned in this research were subsequently engaged by the donors for carrying out the manufacture of the enamel on a large scale.

The Fellowship on glass led to results of direct utilitarian value in the discovery of a glass of a particularly high index of refraction, and indirectly to a novel method of measuring the surface tension of molten glass.

Mr. Weidlein's investigation on the ductless glands of deep sea mammals led to interesting scientific results. He visited Labrador, and, with the help of Dr. Grenfell, collected material for subsequent examination. His results are published, in part, in a paper on "Epenephrin from the Whale" (Journal of Industrial and Engineering Chemistry, Vol. 4, No. 9; September 1912), in which he shows that epenephrin is present in the suprarenal glands of the whale, and that the product, if carefully purified by a method described and injected intraveneously, gives a marked increase of the blood pressure which is not followed by the depressant action observed in commercial epenephrin. This depressant action he believes to be due to impurities present in the gland, and to oxidation products.

The investigation on wood and varnish supervised by Dr. Redman has resulted in the production of a new material, somewhat resembling celluloid, which has most valuable properties for use in various industries.

It is at present too early to describe in detail the researches in progress at Pittsburgh University. Reference may, however, be made to the exhaustive and well-organised research on the smoke nuisance, a problem which, it may be noted, has also been systematically studied in the University of Leeds. This research, though of commercial and industrial importance, has obviously a direct social value, and the endowment, provided by some well-known business men in Pittsburgh, whose names have not been published, is in the nature of a public benefaction. A large staff of investigators has been organised under Dr. Raymond C. Benner, capable of studying the question from all points of view, chemical, physical, medical, economic, legal, and architectural. An outline of the programme of the research has been published by the University, from which the following particulars are extracted :—The staff is composed of 24 specialists, six of whom are giving their whole time to the work, the remaining members being charged with the preparation of special reports. The investigation is divided roughly into two parts—the analytic or diagnostic, and the constructive or remedial ; the former being concerned with the meteorological, botanical, chemical, physical, architectural, hygienic, medical, and economic aspects of the question ; and the latter with propaganda work, together with a study of the engineering problems and legal administration involved in the suppression of the smoke nuisance. A brief history of the smoke nuisance in Europe and the United States, and an exhaustive bibliography are being prepared. Dr. H. Kemball has been entrusted with the task of determining the effects of smoke and soot upon fogs, winds, temperature, sunlight, and weather conditions, with particular reference to soft coal communities like Pittsburgh. The data obtained will enable an estimate to be formed of the increased cost of artificial illumination due to the smoke-laden atmosphere of Pittsburgh, and will be of value to the physician of the staff in the study of eye-strain in smoky cities. The effect on plant life is being investigated by Mr. J. F. Clevenger, while the chemical aspects of the question, including a study of the composition of soot deposited under various conditions have been studied by Dr. Benner. The physics of smoke offers a wide field for research which may lead to results of great scientific interest.

Thus the shape and size of smoke particles, their physical state,—solid, liquid, and gaseous-occluded conditions—their electrical conditions, and the effect of changes of temperature are to be studied by Dr. W. W. Strong. A group of five architects and experts on building materials, together with an expert on paints, are dealing with such practical questions as the effect of smoke on various materials, and the cost and efficiency of various methods of cleaning these materials. The medical side of the question has so far received little attention, though certain diseases which may be indirectly due to smoke are very prevalent in Pittsburgh, and doubtless in other large industrial cities, and it is suspected that the depressing conditions of life in such cities may diminish vitality and lead to the increased use of intoxicants and stimulants and their resulting moral degradation. Under the scheme, the effect of smoke on various organs, such as the lungs, throat and nose, and eye, predisposition to disease and tardy convalescence, are to be carefully investigated. Estimates have been made for many cities of the economic loss due to smoke which, if even only approximately accurate, are startling and disquieting. A cursory examination will show how numerous are the sources of loss—in the extra cost of cleaning windows, of cleaning and renewing painted surfaces and fabrics, the provision of special means of ventilation, and the increased use of artificial illumination. For Chicago, the loss has been estimated at 10,000,000*l*. per annum, and for the whole of the United States at 100,000,000*l*. per annum. The economists on the Pittsburgh staff are collecting data, and hope to arrive at a fairly accurate estimate of the total loss suffered in Pittsburgh owing to smoke. The other branch of the research is legal and social rather than scientific in character. It will study the laws and ordinances concerning smoke, taking up the question of legal regulation and educating the public on the question. It will concern itself with the question "Who makes the smoke?", and whether smoke is industrially necessary or not. Special attention is to be given to fuel-burning devices now in use, with particular reference to smokeless combustion in boilers, metallurgical, and other furnaces using bituminous coal. Advice on these matters is to be offered to manufacturers, and means will be adopted for dealing with recalcitrant offenders. Experimental methods of precipitating smoke electrically or otherwise are to be studied, and an attempt is to be made to devise an accurate method for giving warning of the production of smoke, a "smoke monitor and recorder," and for measuring its density. It would be difficult to over-estimate the value of an investigation so useful in its aims, so comprehensive in its scope, and so well-organised in its methods. By such means the City University can leave the impress of its work on the whole population, and justify itself even to those who may not appreciate the more indirect benefits of higher education.

An attempt may now be made to consider certain possible criticisms of Dr. Duncan's scheme, some of which may not be completely answered by the information already given. First, and perhaps most important, is the question how far the fellowships tend to promote chemical knowledge and scientific progress. Dr. Duncan asserts that no fellowship has been accepted which did not appear to offer a reasonable chance, if properly conducted, of adding to chemical knowledge in a wide sense. The terms of the contract are expressed in the broadest and most general sense, and none of the donors has attempted unduly to restrict the scope of any inquiry, nor would any attempt at dictation on the matter be tolerated. The problems to be investigated are usually approached, it must be remembered, not from the "inside." Thus the man who took up the question of varnish and wood-finishing came new to the problem. As a preliminary to his research, he was directed to absorb all the current knowledge of varnish, to go into a factory and learn to varnish, to visit a number of varnish factories, to make a series of varnishes, and finally, to study the "pure science" abstracts for the past five years solely from the standpoint of new scientific knowledge bearing on the finish of wood. Again, the discovery of the new enamel, to which reference has been made, depended on new chemical knowledge. The investigation in glass led to the discovery of an industrial glass with a peculiarly high index of refraction, and incidentally, to a new and accurate method of investigating the surface tension of molten glass and other colloidal bodies, about which virtually nothing was previously known. Other examples might be given.

Another question which may be asked is whether the scheme provides training for the men who are appointed to the Fellowships. An inspection of the names and degrees of the Fellows indicates that both young men and others of mature age and experience have been appointed. For the younger men, minor fellowships with emoluments of 100*l*. to 200*l*. a year, are provided. Their researches, though of an industrial character, are accepted as preparation for the doctor's degree and their course of training resembles that for doctors in other scientific departments of the University, minor subjects of an allied character being taken in addition to the major subject. Dr. Duncan claims, however, that the industrial researches in which the Fellows are engaged are of a higher character and demand more initiative than the average research for the doctorate. He instances the research on the extraction of casein from buttermilk. Casein is a phosphoprotein, and the research demanded a close study of all allied substances. It is also a colloid, and the chemistry of colloids had to be mastered, together with the influence of electrolytes on their precipitation and the influence of soluble salts on the precipitation of casein. Colloids of iron, copper, and platinum, were made by Bredig's method. The electrical charge carried by the colloid was also investigated and a number of combustion analyses made in the ordinary way by the use of Na_2O_2. The electrical conductivity of salts was determined and curves plotted; a course in bacteriology and in enzymes and fermentation was necessary, as well as in physiological chemistry. The action of adulterants and preservatives of milk upon casein was studied; and the effect of the heat of pasteurisation upon casein, milk, sugar, and lactic acid. The amino acids, and the hydrolysis products of casein with acids and enzymes were investigated, and, since casein is used in the paper, paint, dyeing, and other industries, some knowledge of these materials had to be obtained. Emil Fischer's work on the hydrolysis of proteins was studied. Only by comprehensive study of this kind was a successful result achieved for the research. It can safely be said that many researches in pure chemistry for which the doctorate has been granted would compare unfavourably in range and complexity with this research, which is fairly typical of many which have been taken in Dr. Duncan's laboratories. There is no evidence that the character of the researches has been degraded by their commercial associations. A tendency may have shown itself in a few cases through an over-anxiety to obtain results, to adopt "hit and miss" methods, but speaking generally the spirit in which the researches have been conducted has been in the best sense scientific.

A third question which may be asked is whether these researches could not be carried out with greater success by the manufacturer in his works. Dr. Duncan asserts that the problems selected are such as demand two or three years of intensive effort under conditions as to laboratory and library facilities, and with advantages arising from consultation and an inspiring environment which cannot be obtained at the present time in American factories. The manufacturer can offer factory facilities for large scale operations and a knowledge of contemporary practice of the art, but these he can equally offer to the industrial Fellow working in a University laboratory. There are, no doubt, many researches which could only be carried out in the factory itself. But Dr. Duncan's scheme has demonstrated that there remains a wide range of scientific researches of an industrial or applied character which can be successfully undertaken in the University laboratory.

A few words must be said, in conclusion, on a feature of internal University organisation in relation to the scheme, to which Dr. Duncan attached great importance. He insisted that the department of applied science over which he presided should be granted by the University a full measure of autonomy. Universities both at home and abroad have been subjected to a good deal of criticism for what are called their "academic" traditions and methods. The pursuit of science for its own sake is in a certain degree incompatible with the pursuit of science for direct utilitarian objects, though the two aspects cannot and ought not to be completely divorced and are certainly not mutually exclusive in a University. Dr. Duncan felt, however, that his particular work might be hampered and restricted if controlled by any committee in which pure scientists were given a large representation; and, while prepared to work in friendly co-operation with the other scientific departments of the University, he insisted that there should be no undue interference with the work of his own department.

The Industrial Research Department at Pittsburgh, which for two or three years was carried on in a temporary building, led to the establishment and endowment in the University of the Mellon Institute of Industrial Research and School of Specific Industries of the University of Pittsburgh, the donors being the brothers Andrew W. Mellon and Richard B. Mellon, bankers and prominent citizens of Pittsburgh. The objects of the Institute are stated to be:—

> "The increase of useful knowledge through the application of contemporary science to industrial processes, the promotion of American industry, and providing opportunities for the training of men for high industrial appointments, and, in addition to this, the training of men in advanced chemical engineering and industrial chemistry for specific industries."

The capital amount of the benefaction for the establishment of the Institute was about 100,000*l*., half of which was used for the permanent building, 12,000*l*. for equipment and apparatus, 4,000*l*. for the chemical library, and 8,000*l*. a year for at least five years for maintenance. Accommodation is provided for 70 research workers, and for a number of graduate students studying specific industries. Equipment is provided for large-scale operations, special plants being built when the work cannot be carried out with greater efficiency in the factory. A description of the building of the Institute is printed in Appendix III. (pp. 25–29 below).

The Institute, which is an integral part of the University, is controlled by a committee of nine members, five of whom were appointed in the first instance by the donors. In case of an occasional vacancy among these five members, a successor will be appointed by the remaining members of the class. The other four members are appointed by the Trustees of the University. The Director is appointed by the Committee and acts as Secretary to the Committee, and the status in the University of the staff of the Institute is guaranteed.

The establishment of the Mellon Institute consummates the great work which Dr. Duncan has carried out in the development of industrial research. His untimely death in February, 1914, withdrew his inspiring influence and personality; but the general lines of the work having been laid down with so much skill and knowledge, its future development may be safely left in other hands.

Dr. Duncan is succeeded at Pittsburgh as Director of the Institute by Dr. Raymond F. Bacon, who was previously Associate Director and, in that capacity, took a large share of the work of organisation and supervision. Dr. Duncan retained his professorship in the University of Kansas until 1913, having been permitted for some time to hold professorships in both the University of Kansas and the University of Pittsburgh.

It is a matter for regret that Dr. Duncan's scheme was abandoned in the University of Kansas soon after his resignation of his professorship in 1913. The University of Kansas is a State University, and the scheme, though in a large measure self-supporting, received for some years an annual subscription from the State of 1,100*l*. per annum. The conclusion was reached that this expenditure on the part of the State was not justifiable, and the scheme has been replaced by a small organisation known as the Division of State Chemical Research, which devotes itself to the study of problems of a public character and of special interest to the State, by the methods of chemical research, such as natural gas, water-softening systems, sewage disposal, the occurrence of potash in the salt-beds of the State, and the recovery of zinc by flotation from tailings. The work of the department is supervised by the University Professor of Chemistry, Mr. W. A. Whitaker, who divides his time between teaching and research.

THOMAS LLOYD HUMBERSTONE.

August, 1915.

APPENDIX I.

COPY OF AGREEMENT BETWEEN THE MANUFACTURER AND THE MELLON INSTITUTE OF THE UNIVERSITY OF PITTSBURGH RELATING TO THE ESTABLISHMENT OF AN INDUSTRIAL FELLOWSHIP.

........................COMPANY'S FELLOWSHIP AGREEMENT.

THIS AGREEMENT, made and entered into this .... day of ...., 19......, between the Mellon Institute of the University of Pittsburgh, of the City of Pittsburgh, Pennsylvania, hereinafter called the "Institute," and the .... of ...., ..., hereinafter called the "Company."

WITNESSETH that for the purpose of promoting the increase of useful knowledge, the parties hereto agree as follows:—

1. The Company shall pay to the Institute annually in advance for a period of .... years, beginning ...., 191......, the sum of .... dollars ($...............) for the foundation of an Industrial Fellowship to be known as .... FELLOWSHIP, the exclusive purpose of which is ....

2. The Institute shall accept the sums so to be furnished by the Company and shall devote them to the furtherance of the problem of this Fellowship; and to this end all money received from the Company under this Agreement shall be paid over by the Institute in monthly instalments to the holder of this Fellowship, in such amount as may be agreed upon by the Institute and the Fellow concerned, and expended for such apparatus and supplies related to this research as the Director of the Institute may deem it advisable to purchase and for travelling expenses related to the elucidation of the problem concerned. The Fellow shall be provided, at the expense of the Institute, with a separate laboratory and with such apparatus, supplies and reagents as in the opinion of the Director constitute a reasonable provision. The Company, on its part, shall co-operate with the Institute in this research by providing the Director thereof and the Fellow of this Fellowship with its sympathy and whatever knowledge of the subjects of research it may possess, and, on approval of the Company, with its factory facilities for large-scale experimentation.

3. The holder of the Fellowship provided hereunder shall be appointed by the Committee of Management of the Institute upon the nomination of the Director in accordance with the terms of his formal letter of application to and as approved by the Director, and he shall give his whole time and attention to the object of the Fellowship, with the exception, if the Director so elect, of three hours a week which he shall give to instructional work in the University of Pittsburgh. The Fellow shall work under the advice and direction of the Director and shall from time to time through the Director forward to the Company reports of the progress of his work. During the existence of the Fellowship provided hereunder the Company shall have the right, through and with the acquiescence of the Director, to employ and take into its regular service the Fellow of this Fellowship, upon terms to be agreed upon between the Fellow and the Company.

4. The Institute, at the expiration of the Fellowship. shall return to the Company any money paid to it by the Company, in case any thereof shall remain unexpended for the purpose of this Fellowship.

5. Any and all discoveries made by the Fellow during the term of this Fellowship, as well as all information obtained by him germane to the subject of his investigation, shall become the property of the Company, subject to the terms and provisions of this Agreement, and the Fellow making such discovery or obtaining such information shall promptly and without demand make revelations of all such information and discoveries. Such revelations shall be made to the duly-designated representatives of the Company directly, or through the Director, as the Director may determine.

6. The Fellow of this Fellowship making a discovery or invention germane to the subjects of his investigation shall, at any time, at the option and expense of the Company. apply for letters patent, and shall upon demand assign such letters patent and any and all rights to such invention to the Company under the conditions of this Agreement. In case the Company desires to keep secret such discovery or invention, or for any reason desires that letters patent shall not be applied for, the Fellow shall not at any time apply for patent or patents in his own name, and shall not disclose such discovery or invention to others except as herein provided.

7. The Company shall, in addition to the sum paid to the Institute as foundation for the Fellowship, pay to the Fellow a maximum cash bonus of .... dollars ($ ....) or any part thereof which in the opinion of the Board of Arbitration (hereinafter provided for) is deserved by the Fellow of this Fellowship, and the amount of this payment and the time or times of payment shall be decided by the Board of Arbitration upon application of either of the parties hereto.

8. In the event of any difference of opinion between the parties hereto as to the interpretation of this Agreement, or the rights of the respective parties to this Agreement, the matters in issue shall be referred to a Board of Arbitration, which Board shall consist of a representative of the Institute and a representative of the Company, and a third person whom these two shall select. The decision of this Board shall be obtained without recourse to the Courts and when rendered shall be binding upon the parties hereto.

9. During the term of this Fellowship, the holder thereof may publish such results of his investigation as do not, in the opinion of the Company, injure its interests. On or before ...., 19 ......, the holder shall have completed a comprehensive monograph on the subjects of his research. The subject-matter of such monograph shall not contain specific information of the process or methods of the Company, but it shall be confined to a statement of new discoveries of scientific fact obtained by this Fellowship, and such statement shall not contain data or information in regard to the cost of manufacture by any process revealed in such statement. A copy of this monograph shall be forwarded to the Company and a copy shall be signed and placed in the archives of the Institute until the expiration of three years from the time hereinafter provided for the termination of this Fellowship, when the Institute shall be at liberty to publish it for the use and benefit of the public.

In the event that in the opinion of the Company such publication at such time will unduly injure its interests, it shall have the privilege of appealing at any time for an extension of time of such publication to the Board of Arbitration provided for herein, which after considering the appeal shall, if in its opinion such publication will unduly injure the Company's interests, extend the time of publication to a time when in the Board's opinion publication will not unduly injure the interests of the Company.

10. The Fellowship provided under this Agreement shall terminate the .... day of ...., 19 ....

In witness whereof the parties hereto have caused their names to be subscribed the day and year above mentioned by their duly authorised officers.

Mellon Institute of University of Pittsburgh.

By ....

....

By ....

Witness—

....

....

APPENDIX II.

[*Note.*—Dollars are converted into pounds at £1 = $5.]

A. UNIVERSITY OF PITTSBURGH FELLOWSHIPS.

1. BAKING.

150*l.* a year for two years.
Fellow :—Wilber A. Hobbs, B.S. (University of Kansas).
(November 30, 1910.)

2. ABATEMENT OF THE SMOKE NUISANCE.

2,400*l.* 1st year; 3,000*l.* 2nd year; 2,400*l.* 3rd year.

Staff in Charge.

Fellows :—

R. C. Benner, Ph.D. (University of Wisconsin), Chief Fellow, 1st and 2nd years.
J. J. O'Connor, Jr., M.A. (University of Pittsburgh), Economist and Chief Fellow, 3rd year.
W. W. Strong, Ph.D. (Johns Hopkins), Physicist.
A. F. Nesbit, B.S. (Massachusetts Institute of Technology), Electrical Engineer.
J. A. Beck, LL.B. (University of Pittsburgh), Attorney.
E. H. McClelland, Ph.B. (Lafayette College, Easton, Penn.), Bibliographer.
O. R. McBride, B.S. (Purdue University), Mechanical Engineer.
J. E. W. Wallin, Ph.D. (Yale University), Psychologist.
H. H. Kimball, Ph.D. (George Washington University, Washington), Meteorologist.
A. B. Bellows, B.S. (Massachusetts Institute of Technology), Mechanical Engineer.
J. F. Clevenger, M.S. (Ohio State University), Botanist.
C. H. Marcy, A.B., Bacteriologist.

Advisory Staff.

Oskar Klotz, M.D., C.M. (McGill University), Senior Fellow.
E. W. Day, A.M., M.D. (Georgetown University, Washington).
W. C. White, M.D. (Toronto University).
R. T. Miller, Jr., M.D. (Johns Hopkins University).

W. W. Blair, M.D. (Hahnemann Medical College of the Pacific, San Francisco).
B. A. Cohoe, A.B., M.D. (Toronto University).
S. R. Haythorn, M.D. (University of Michigan).
W. L. Holman, M.D. (McGill University).
E. B. Lee, Architect, Senior Fellow.
Richard Hooker, B.S., Architect.
C. T. Ingham, Architect.
Richard Kiehnel, Architect.
Carlton Strong, Architect.
K. K. Stevens, B.S., Chemist.

(November 30, 1910; revised June 24, 1911.)

3. ON THE RELATION OF THE POTS TO GLASS IN GLASS-MAKING AND THE ELIMINATION OF "STREA."

300*l*. a year for two years. Bonus, 400*l*.
Fellow:—Samuel R. Scholes, Ph.D. (Yale University).

(January 25, 1911.)

4. BAKING.

(Wholly independent of, but with acquiescence of, No. 1.)

950*l*. a year for two years. Bonus, cash, 2,000*l*.
Fellows:—
Henry A. Kohmann, Ph.D. (University of Kansas), Senior Fellow.
Charles Hoffman, Ph.D. (Yale University).
Alfred E. Blake, A.B. (New Hampshire College).

(January 25, 1911.)

5. GLUE.

240*l*. a year for two years.
Fellow:—Ralph C. Shuey, B.S. (University of Kansas).

(February 3, 1911.)

6. SOAP.

240*l*. a year for two years.
Fellow:—Paul R. Parmelee, B.S. (University of Kansas).

(February 3, 1911.)

7. UTILISATION OF FRUIT WASTE.

200*l*. a year for two years. Bonus, 2,000*l*.
Fellow:—F. Alexander McDermott (George Washington University).

(May 12, 1911.)

8. COMPOSITION FLOORING.

300*l*. a year for two years. Bonus, 1 per cent. of sales for five years.
Fellow:—R. R. Shively, B.S. (Oklahoma Agricultural and Mechanical College).

(August 15, 1911.)

9. CRUDE PETROLEUM.

2,000*l*. a year for three years, including apparatus fund. Bonus, collective interest, 10 per cent.

Fellows:—

Benjamin T. Brooks, Ph.D. (University of Göttingen), Senior Fellow.
Clinton W. Clark, M.A. (Ohio State University).
Lester Pratt, M.S. (New Hampshire College).
Hugh Clark, M.A. (Ohio State University).
Arthur H. Myer, A.M. (Leland Stanford Junior University).
Frederick Padgett, M.S. (University of Pittsburgh).
F. W. Bushong, Sc.D. (Emporia College, Emporia, Kansas)
J. W. Humphreys, M.S. (University of Kansas).
George W. Stratton, Ph.D. (Ohio State University).
Harold Hibbert, D.Sc. (Victoria University of Manchester).
Harry Essex, Ph.D. (University of Göttingen).

(September 22, 1911.)

10. NATURAL GAS.

800*l*. a year for two years; 1,200*l*. 3rd year including apparatus fund. Bonus, 5 per cent. on industrial results.

Fellows:—

R. H. Brownlee, Ph.D. (University of Chicago), Senior Fellow.
Roy H. Uhlinger, M.A. (University of Pittsburgh).

(September 22, 1911.)

11. CEMENT.

360*l*. a year for two years. Bonus, 2,000*l*.

Fellow, J. F. MacKey, Ph.D. (University of Toronto).

(September 22, 1911.)

12. FOODS, PROBLEMS RELATED TO THE MANUFACTURE OF.

1,000*l*. a year for two years. Bonus, 2,000*l*.

Fellows:—

Clarence C. Vogt, Ph.D. (Ohio State University), Senior Fellow.
Harry P. Corliss, Ph.D. (University of Pittsburgh).
Mrs. Lou H. M. Vogt, Ph.D. (Ohio State University).

(May 20, 1912).

13. FATS AND OILS, BLEACHING OF.

360*l*. a year for two years and 60*l*. apparatus fund.

Fellow, Leonard M. Liddle, Ph.D. (Yale University).

(May 22, 1912).

14. EFFECT OF HIGH POTENTIAL ELECTRICITY ON CHEMICAL REACTION.

200*l*. a year for two years and 60*l*. apparatus fund, and an additional consideration.

Fellow, W. E. Vawter, B.S. (University of Kansas).

(October 28, 1912.)

15. DISCOVERY OF METHODS OF COATING STEEL OR OTHER METALS WITH COPPER OR OTHER METALS.

300*l*. a year for one year, 100*l*. apparatus fund, three months' extension. Bonus, 2,000*l*.

Fellow, C. L. Perkins, B.S. (New Hampshire College).

(December 4, 1912).

16. EXTRACTION OF COPPER FROM ITS ORES AND FROM COPPER "TAILINGS."

300*l*. a year for one year.

Teaching fellow, Howard D. Clayton, B.A. (Ohio State University).

(December 1, 1912).

17. DESERT PLANT, AND ADDITIONAL PROBLEM.

300*l*. a year for one year, 60*l*. apparatus fund. Bonus, a 7 per cent interest.

Fellows:—

R. R. Shively, Ph. D (University of Pittsburgh).
Alfred E. Blake, M.S. (University of Pittsburgh).

(January 31, 1913.)

18. BAKING.

1,200*l*. a year for two years, 100*l*. apparatus fund. Bonus, 2,000*l*.

Fellows:

Henry A. Kohmann, Ph. D. (University of Kansas), Senior Fellow.
Charles Hoffman, Ph.D. (Yale University).
Trueman M. Godfrey, B.S. (University of Kansas).
Lauren H. Ashe, B.S. (University of Pittsburgh).

(May 12, 1913.)

19. ALUMINIUM.

1,000*l*. a year for two years, including apparatus fund. Bonus, 2,000*l*.

Fellows:—

Hugh Clark, Ph.D. (University of Pittsburgh).
Lester A. Pratt, Ph.D. (University of Pittsburgh).
Frank D. Shumaker, B.S. (University of Pittsburgh).

(May 12, 1913.)

20. GLUE.

300*l*. a year for two years, 60*l*. apparatus fund.

Fellow, Ralph C. Shuey, B.S. (University of Kansas).

(May 12, 1913.)

21. SOAP.

300*l*. a year for two years, 60*l*. apparatus fund.

Fellow, Ben H. Nicolet, Ph.D. (Yale University).

(May 12, 1913).

22. GLASS.

300*l*. a year for two years, 60*l*. apparatus fund. Bonus, 700*l*.

Fellow, R. R. Shively, Ph.D. (University of Pittsburgh).

(July 14, 1913.)

23. RELATION OF ELECTRICAL POTENTIAL TO CATALYTIC ACTION.

300*l.* a year for two years, 60*l.* apparatus fund. Bonus, 5 per cent. on industrial results.

Fellow, Frank F. Rupert, Ph.D. (Massachusetts Institute of Technology).

(July 14, 1913).

24. EXTRACTION OF COPPER FROM ITS ORES AND FROM COPPER "TAILINGS."

300*l.* a year for one year, 60*l.* apparatus fund.
Fellow, Charles O. Brown, A.M. (Cornell University).

(July 14, 1913.)

25. YEAST.

1,040*l.* a year for two years, including apparatus fund. Bonus, 2,000*l.*

Fellows:—

F. Alex. McDermott, M.S. (University of Pittsburgh), Senior Fellow.
William Smith, B.S., Scholar (University of Pittsburgh).
Ruth Glasgow, M.S. (University of Illinois), Bacteriologist.
James C. Cuthbert, Scholar (University of Pittsburgh).
Lauren Hewitt Ashe, B.S., Scholar (University of Pittsburgh).

(July 14, 1913.)

26. HARDENING OF FATS.

200*l.* a year for one year, 60*l.* apparatus fund. Bonus, a 49 per cent. interest.
Fellow, E. O. Rhodes, B.S. (University of Kansas).

(September 19, 1913.)

27. LEATHER SCRAP.

200*l.* a year for one year, 40*l.* apparatus fund. 30*l.* second year, including apparatus fund. Bonus, a 10 per cent. interest.
Fellow, R. Phillips Rose, M.S. (University of Kansas).

(October 22, 1913.)

28. FERTILIZER.

500*l.* a year for two years, including apparatus fund. Bonus, 1,000*l.*
Fellow, Earl S. Bishop, D.Sc. (Queen's University, Ontario).

(November 1, 1913.)

29. COPPER.

1,200*l.* a year for one year including apparatus fund.

Fellows:—

E. R. Weidlein. A.M. (University of Kansas), Senior Fellow.
H. D. Clayton, B.A. (Ohio State University).
G. A. Bragg, B.S. (University of Kansas).

(November 6, 1913.)

30. RADIATORS.

400*l.* a year for two years including apparatus fund.
Fellow, J. C. Ballantyne, B.Sc. (University College, London), M.S. (University of Pittsburgh).

(November 18, 1913.)

31. TURBINE ENGINES.

360*l*. a year for one year including apparatus fund. Bonus, 600*l*.
Fellow, Rudolph McDermet, M.S. (University of Illinois).

(January 5, 1914.)

32. GLASS.

360*l*. a year for one year including apparatus fund. Bonus, a 25 per cent. interest.
Fellow, Harvey G. Elledge, B.S. (University of Kansas).

(January 5, 1914.)

33. [Particulars not published.]

34. FATTY OILS.

420*l*. a year for one year, including apparatus fund.
Fellow, Leonard M. Liddle, Ph.D. (Yale University).

(July 1, 1914.)

35. ORES.

1,060*l*. a year for one year, including apparatus fund.
Fellows :—
Charles O. Brown, A.M. (Cornell University).
James B. Garner, Ph.D. (University of Chicago).
Clement L. Perkins, B.S. (New Hampshire College).
E. R. Weidlein, A.M. (University of Kansas), Senior Fellow, Advisory.
G. A. Bragg, B.S. (University of Kansas), Advisory.
H. D. Clayton, B.A. (Ohio State University), Advisory.

(June 15, 1914.)

36. FLOTATION.

640*l*. a year for one year, including apparatus fund.
Fellows :—
Harry P. Corliss, Ph.D. (University of Pittsburgh).
Clarence L. Weirich, M.S. (University of Pittsburgh).

(June 15, 1914.)

37. ACETYLENE.

600*l*. a year for one year, including apparatus fund. Bonus, 1,000*l*. maximum.
Fellow, George O. Curme, Jr., Ph.D. (University of Chicago).

(November 15, 1914.)

38. DENTAL SUPPLY TRADE PROBLEMS.

640*l*. a year for one year, including apparatus fund.
Fellows :—
Clarence C. Vogt, Ph.D. (Ohio State University).
H. Edmund Friesell, D.D.S. (Pennsylvania Dental College), Advisory.

(July 1, 1914.)

39. FAT COMPOUNDS.

500*l*. a year for one year, including apparatus fund.
Fellow, Edmund O. Rhodes, M.S. (University of Kansas).

(October 1, 1914.)

40. STONE.

360*l*. a year for one year, including apparatus fund.
Fellow, H. C. Holden, M.S. (New Hampshire College).

(October 26, 1914.)

41. COPPER.

1,200*l*. a year for one year, including apparatus fund.
Fellows :—

E. R. Weidlein, A.M. (University of Kansas), Senior Fellow.
H. D. Clayton, B.A. (Ohio State University).
G. A. Bragg, B.S. (University of Kansas).

(November 1, 1914.)

42. GLASS.

360*l*. a year for one year, including apparatus fund.
Fellow, John F. W. Schulze, Ph. D. (Clark University).

(December 3, 1914.)

43. LAUNDERING.

360*l*. a year for one year, including apparatus fund.
Fellow, Harvey G. Elledge, B.S. (University of Kansas).

(February 1, 1915.)

44. LAND DEVELOPMENT.

200*l*. a year for one year.
Fellow, Will E. Vawter, B.S. (University of Kansas).

(February 1, 1915.)

B.—UNIVERSITY OF KANSAS FELLOWSHIPS.

1. LAUNDERING.

100*l*. a year for two years, and 10 per cent. of net profits.
Fellow, Fred Faragher, A.B.

(January 1907.)

2. DIASTASE.

100*l*. a year for two years, and 10 per cent. of gross profits.
Fellow, Ralph C. Shuey, B.S.

(June 1907.)

3. BREAD.

100*l*. a year for two years, and an additional consideration.
Fellow, H. A. Kohmann, A.B.

(April 1908.)

4. CASEIN.

100*l*. a year for two years, and 10 per cent. of net profits.
Fellow, E. L. Tague, A.M.

(April 1908.)

5. PETROLEUM.

200*l*. a year for two years, and 10 per cent. of net profits.
Fellow, F. W. Bushong. Ph. D.

(April 1908.)

6. ENAMEL.

260*l*. a year for two years.
Fellows :—
A. J. Weith, B.S.
F. P. Brock, B.S.

(September 1908.)

7. GLASS.

300*l*. a year for four years and 10 per cent. of net profits.
Fellow, E. Ward Tillotson, Ph. D.

(March 1909.)

8. CEMENT.

300*l*. a year for two years, and an additional consideration.
Fellow, J. F. MacKey, Ph.D.

(March 1909.)

9. VARNISH.

300*l*., 1st year; 540*l*., 2nd year; 780*l*. and an additional consideration, 3rd year.
Fellows :—
1st year, L. V. Redman, Ph.D.
2nd year, L. V. Redman, Ph.D., Senior Fellow.
2nd year, A. J. Weith, B.S.
2nd year, F. P. Brock, B.S.

(November 1909.)

10. BORAX.

150*l*. a year for two years.
Fellow, B. C. Trichot, B.S.

(November 1909.)

11. DUCTLESS GLANDS OF DEEP SEA MAMMALS.

200*l*. a year for two years and an additional consideration.
Fellow, E. R. Weidlein, A.B.

(March 1910.)

12. VEGETABLE IVORY.

300*l*. a year for two years, and 400*l*. bonus.
Fellow, J. P. Trickey, A.B.

(June 1910.)

13. PETROLEUM.

550*l*. a year for two years, and 1,000*l*. bonus.
Fellows:—
F. W. Bushong, Ph.D., Senior Fellow.
J. W. Humphreys, B.S.

(April 1911.)

14. GILSONITE.

150*l*. a year for 1 year and 400*l*. bonus.
Fellow, W. E. Vawter, B.S.

(April 1911.)

15. FATS, HARDENING OF.

260*l*. a year for two years, and a 49 per cent. interest.
Fellow, E. O. Rhodes.

(September 1912.)

16. LEATHER SCRAP.

240*l*. a year for two years, and a 10 per cent. interest.
Fellow, R. Phillips Rose, A.B.

(October 1912.)

17. COPPER.

360*l*. for one year, 100*l*. apparatus fund, and an additional consideration.
Fellow, E. R. Weidlein, A.M.

(November 1912.)

18. COPPER.

200*l*. for one year, and an additional consideration.
Fellow, G. A. Bragg, B.S.

(November 1912.)

APPENDIX III.

New Building of the Mellon Institute, University of Pittsburgh.

The following description of the new building of the Mellon Institute in the University of Pittsburgh is quoted from an article by Mr. W. A. Hamor published in the Journal of Industrial and Engineering Chemistry (April 1915):—

"The ground plan of this five story and attic laboratory building was laid out to secure the greatest amount of light, air and compactness. The basement contains seven rooms: the main storeroom, the boiler room, the electric furnace room, a heavy apparatus room, a room equipped for low-temperature work, the machine shop, and a kitchen. On the first, the main, floor, are located the general office, the Director's suite, the office of the editorial department, the library, the office and laboratory of the Assistant Directors, the Assembly Hall, a special apparatus room, and a dark-room laboratory. The second and third floors each contain ten large research laboratories and nine small ones; the fourth floor, which is not finished, will contain an identical number of laboratories as soon as the growth of the Institute warrants its completion.

"The facilities which the Mellon Institute now offers for research are primarily instanced in its

Research Laboratories.

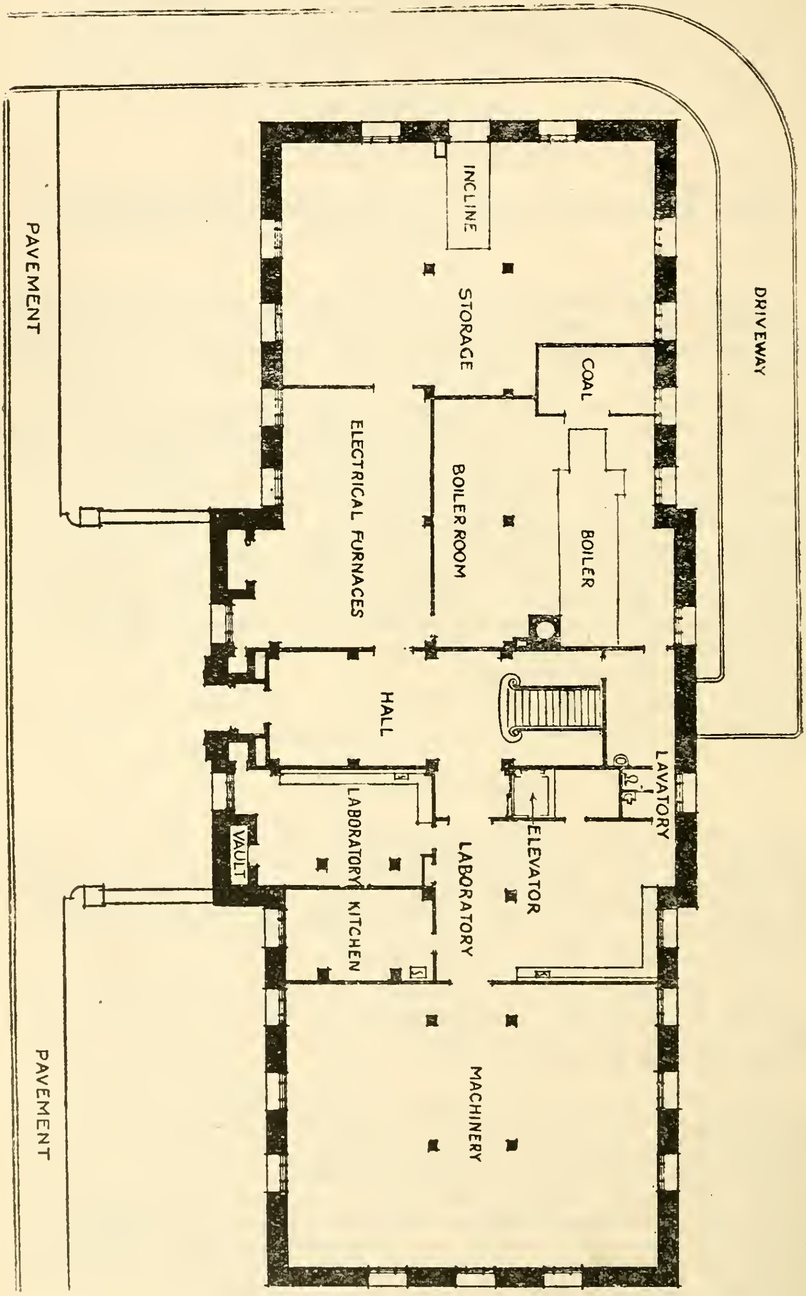
"In general, there are two sizes of research laboratories for the use of the Fellows of the Institute; twenty laboratories 20 ft. 6 in. × 20 ft. 6 in. and eighteen laboratories 10 ft. 6 in. × 20 ft. 6 in., on the second and third floors, have been finished and assigned. This number will later be increased by ten large laboratories and nine small ones on the fourth floor. All laboratories are connected with the general office by an electric call bell.

"The laboratories are not too deep for good light throughout from without. To ensure the latter, the ceiling on the second floor was made 10 ft. 8 in. in the clear from the floor; on the third and fourth floors, the ceilings are 10 ft. 2 in. above the floors.

"*Laboratory Tables.*—The laboratory table tops, which are supported on pipe standards, and are 3 ft. 1 in. clear from the floors and 2 ft. wide, are constructed throughout the building of alberene stone, 2 in. in thickness. All table tops have a ¼-in. slope to the back, with a 3-in. gutter, cut in the top, having a fall to the sinks; and there is a drip cut in the underside of each, on the outer edge, to prevent dripping. Each table is equipped with four sets of gas, water, vacuum, and compressed air supplies; the water outlets are ½-in., all others are ⅜-in. On each table there is an alberene stone back, 14 in. high and 1¼ in. thick; this is equipped with A. C. and D. C. plugs.

"Above the tables are two alberene shelves, 1¼ in. thick × 7 in. wide, and a top shelf, 12 in. wide; the shelves are spaced 14, 10 and 12 in. respectively, and are supported on alberene stone slab-brackets, with a curved front at the top to meet the 12 in. shelf.

Basement Floor Plan, Mellon Institute of Industrial Research.



“ In each laboratory there are three 14 × 20 in. porcelain-enameled sinks. These sinks are set on $\frac{3}{4}$-in. galvanised pipe-frames, having flanges on the floors, with braces half-way up and binders on top, and so put up that the tops of the sinks set 3 ft. above the floors ; the frames received two coats of asphaltum paint after being installed. Each sink has a $1\frac{1}{4}$-in. extra strong lead waste pipe, fastened to the board under the table, with open ends emptying into the receptors.

"There are alberene stone drain boards, 20 × 39 in., back of each sink; these boards are equipped with rubber-tipped wooden pegs. There is also one set of gas, water, vacuum, and compressed air lines over each sink.

"In each large laboratory there are nine sections of one large and two small drawers each, with a compartment underneath, provided with double doors, fitted with friction catches and wooden knobs. In the small laboratories there are eight sections of drawers.

"The cupboards or cases on the first floor are made of quarter-sawed white oak; on all other floors the construction is of plain-sawed red oak.

"*Hoods.*—All laboratories, large and small, are provided with one double hood, 6 ft. long over all, constructed of alberene stone; the inside measurements are: 1 ft. 6 in. deep × 5 ft. 8 in. long × 4 ft. 3 in. high. Each hood is equipped with two sliding sashes, glazed with polished plate wire-glass; the sashes are suspended on bronze sash chains and are balanced with lead weights. At the end of each hood is a light of polished plate wire-glass, 12 × 26 in.

"In each hood there are an A. C. plug, gas, water, steam, vacuum, and compressed air outlets. In one end of every hood a 3-in. opening connects with the hood-ventilating system.

Laboratories for Special Work.

"*Special Apparatus Room.*—On the first floor, a room 38 ft. × 20 ft. 6 in. contains the instruments of precision.

"This room is provided with two alberene stone tables and shelving. There is also, in the centre of the room, a raised platform, 12 × 18 ft., of reinforced concrete supported on reinforced concrete columns extending down through the basement, with separate footings underneath the columns; this platform and its supporting columns are so arranged that they do not come in contact with any portion of the building construction, there being a ½-in. space around the columns at both floors. A fire-proof vault, 2 ft. 6 in. × 9 ft., is provided for the storage of platinum ware, radium preparations, and other valuable equipment for research.

"*Heavy Apparatus Room.*—The 23 × 33 ft. room adjoining the kitchen in the basement, just off the hall, is equipped with two laboratory tables and with systems of grinding and pulverizing machinery and filter presses.

"*Dark-room Laboratory.*—A special dark-room 16 ft. 4 in. × 18 ft., has been provided on the first floor for work in photography and for photochemical research. It is equipped with two alberene stone work-benches and a hood.

"*Electric Furnace Room.*—A basement room, 20 ft. 6 in. × 37 ft., is fitted up for electric furnace work. There are four power outlets in the floor, and two induction regulators and the important types of electric furnaces are installed.

"*Refrigerating Plant.*—A No. 3 Audiffren-Singrun refrigerating machine, having a cooling effect of 40 lbs. per hour, an ice-making capacity of 27 lbs. per hour, requiring 95 lbs. of condensing water at 70° F. per hour, and 1 to 1¼ H.P., and possessing a speed of 280 R.P.M., is located in the basement in a room 14 ft. 6 in. × 20 ft. 6 in. Adjoining this machine is a cork-lined cold-storage room, 6 × 8 × 7 ft., provided with storage shelves and a bench. The machine is guaranteed to keep this room at 37° F. and to make 50 lbs. of ice per day in summer.

Supplies.

"*The Main Storeroom*, 34 ft. 8 in. × 51 ft. 4 in., is located in the basement. It is furnished with an installation of steel shelving having total shelf surface of 3,200 sq. ft.; the greater portion of this equipment is shelving, the remainder consisting of 96 bins carrying a volume of 1,070 cu. ft. and six double cupboards having a volume of 114 cu. ft. Special provision is made at the ends of the cases for metal racks to care for all glass tubing and rodding. All shelving is finished in acid-proof baked enamel.

"The storeroom is in charge of a curator of supplies whose sole duty is to tend the stock and order materials required by the thirty-eight Fellows now engaged in research. It is in telephonic communication with each floor of the building, and a dumb-waiter, capable of lifting 50 lbs., has been installed for distributing small supplies.

"*Distilled Water.*—A Barnstead automatic water still, having a capacity of 5 galls. per hour, is installed in the attic of the building. The distilled water storage tank has a capacity of 125 galls.; it is constructed of No. 16 gauge galvanised iron, lined throughout with pure block-tin, and is furnished with a tin-lined cover.

"There are six distilled-water fountains throughout the building; five of these are in the corridors and one in the general office. The fountains are supplied by gravity from the storage tank in the attic, through a ¾-in. main of block-tin pipes, with ½-in. block-tin branches to each fountain.

Machine Shop.

"The machine shop occupies one-half of a room 51 ft. 4 in. × 40 ft. 4 in. in the basement. At the present time it is in charge of two skilled mechanicians and is equipped to produce the various special mechanical appliances likely to be required in industrial research. In addition to all necessary small tools and to carpentry and pipe-fitting equipment, there are installed a Lodge-Shipley selective-head motor-driven* lathe, 22 in. × 14 ft. bed; a 12-in. Star motor-driven lathe; a 20-in. Cincinnati motor-driven shaper; a Cincinnati-Bickford plain 30-in. motor-driven radial drill; a 14-in. Washburn motor-driven sensitive drill; a Springfield Manufacturing Company's double-end motor-driven grinder; a 36-in. motor-driven band saw; complete oxy-acetylene welding apparatus; a Schoop metals coating pistol; and a hydraulic press.

Library.

"The library occupies a room 58 × 21 ft. It contains a unit book-stack, 6 ft. 10 in. high, running around the room, which forms adjustable shelves, 10 in. deep; and seven book-stacks running out 6 ft. from the wall. The latter stacks are double, each side having a depth of 8 in., and the total shelf capacity is about 12,000 volumes. Opposite the stacks and along the windowed side of the room are four reading tables, 3 × 5 ft., with four arm-chairs at each. There is also a larger table, 3 ft. 6 in. × 8 ft., for periodical reading, at which table eight people may be seated comfortably at one time. This table faces shelves containing 72 technical periodicals which are received currently by the library. All the woodwork and furniture in the room are solid antique oak.

"At present the library possesses 2,000 carefully selected volumes, not including Government publications and pamphlets, of which there are several thousand.

"Among the features of this library are a file of reprints of the contributions of all the fellows, a file of all patents of the fellows, and a trade catalogue file. This last is a very important department of the library; at present over a thousand catalogues of 415 different firms are on file, and this number is added to daily. There is a complete subject and name index, making all the material accessible.

"The library is in charge of a librarian who is also an expert translator.

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* A floor box for power and light outlets is installed at each machine.

Assembly Hall.

"The assembly hall, located on the first floor, occupies a space 34 ft. 3 in. × 51 ft. 4 in. It is provided with a movable lecture table, and a lantern with cinematograph attachment is installed in the mezzanine floor in the first floor corridor adjacent to the hall.

"This hall is used for seminar work and staff meetings, and as the lecture room of the School of Specific Industries. Its walls are decorated with photographs of eminent chemists and with pennants of the various universities represented on the staff, presented by the Fellows in pledge of their fidelity to the ideals of the Institute.

Corridors.

"The corridors on the second and third, the research laboratory floors, are 10 ft. wide and 161 ft. 6 in. long.

"A dumb-waiter shaft from the basement to the attic has an opening at the end of the corridor on each floor. There are also two drinking fountains, supplied with distilled water, and a telephone in each corridor.

"Medicine chests, provided with the ordinary emergency equipment, and fire-extinguishing apparatus are conveniently located in each corridor."

[*See also next page*]

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